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The gettering effect of gadolinium

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The gettering effect of gadolinium has been confirmed by observing the change of pressure when the metal was evaporated in a vacuum chamber at $\sim 10^{-6}$ torr. The mass spectrometric analysis and structural studies by electron microscope of the films showed the high sorption capacity for hydrogen.

1. Introduction

The gettering action is effectively utilised in the production of ultra-high vacuum. For this reason, a great interest has been developed recently surrounding the gettering effect of different materials. Especially, the materials in the form of thin films as a getter are vital to the vacuum production plants. The tendency of the erbium metals to react with the residual gases is well known (Muller *et al* 1972, Singh & Surplice 1973). Most of the rare earth metals are considered as highly efficient getters, and reaction takes place readily with such gases as hydrogen, water vapour, oxygen, nitrogen, methane, carbon dioxide etc. Curzon & Chlebek (1973), declared gadolinium as an exception among heavy rare earths in not acting as a getter. The purpose of this paper is to report the gettering effect of gadolinium metal when evaporated in a vacuum coating unit and also to explain the effect in terms of the unusual structural phase observed when thin films are formed.

2. Experimental

The gadolinium metals of 99·9% purity, supplied by Koch-Light Ltd., in the form of wire of 1 mm diameter, were evaporated by using Edwards 12EA coating unit. The vacuum chamber was evacuated by means of three-stage water-cooled oil vapour diffusion pumps of diameter 4″, backed by rotary pumps. The ultimate pressure of the diffusion pump was 5×10^{-6} torr. A Pirani gauge was used to measure the backing pressure over the range 0·5 to 0·001 torr and a Penning gauge incorporated in the evaporation chamber, covered the range 5×10^{-3} to 1×10^{-7} torr.

The substrates (either rock salt or glass slides) were placed in the vacuum chamber about 10 cm vertically below the filament source. The metal was evaporated from an electrically heated spirally wound tungsten filament by passing about 50 60 amps of alternating current through it The fall of pressure with time when the gettering action started was recorded by a X-Y chart recorder An impurity analysis has been made for oxygen and hydrogen of 250 A film grown from gadolinium on rock salt by using vacuum fusion AEIMS10 metallurgical mass spectrometer

3 Results and Discussions

The pressure in the vacuum chamber prior to evaporation was 5×10^{-6} torr Because of the degassing of the filament at the beginning of the evaporation, the pressure rose up to 1×10^{-5} torr but as soon as the getting action started, due to the evaporation of the metal, the pressure in the chamber began to come down, and within 45 seconds it dropped at 5×10^{-7} torr and remained steady as shown in the figure The experiments were repeated several times and the same gettering effect was observed At this stage the metal vapour had effectively gettered the residual gases The evaporated molecules of gadolinium metal gettered the residual gases in the chamber, as a result of which the pressure fell and the gettered material condensed along side the wall of the bell jar

Muller *et al* (Muller *et al* 1972, Singh *et al* 1970) showed that erbium thin films had exceptional high sorption activity for hydrogen when this was given by itself or when it was a part of a residual gas mixture. The effect was observed in the present case with the gadolinium thin films It was most reactive towards hydrogen The gadolinium metal has got the hexagonal close pack (h.c p) structure but when evaporated formed the face centred cubic (f c c.) gadolinium dihydrides (Khan 1978, Gasgnier *et al* 1974), at a thickness less than 250A. When the evaporation continued for longer periods, thick films (1000 A) of bulk h c p. structure are formed. Films of intermediate thickness (250–950A) had both f c.c. and h c p. structures The change of structural phases of the films are in agreement with the observed gettering effect of hydrogen The results of the above structural analysis (Khan 1978) by electron diffraction also confirmed that gadolinium had high sorption capacity for hydrogen. Mass spectrometric analysis of the films (250 A) gave the results that it contains 83 atomic percentage of hydrogen and 4·52 atomic percentage of oxygen This is also an additional support for the conclusion that gadolinium is highly reactive towards hydrogen

At the beginning of the evaporation, the gadolinium molecules reacted with residual gases, mainly hydrogen, forming f c c. gadolinium dihydrides but as the evaporation continued for longer period, the gettering effect saturated, forming thick metallic films From the curve it is seen that effective gettering happens within 45 seconds The great affinity of the gadolinium for hydrogen was also observed when a stream of hydrogen was passed at elevated temperature through the newly formed gadolinium dihydride. The hydrogen treated films become converted to h c p gadolinium trihydrides (Khan 1977)

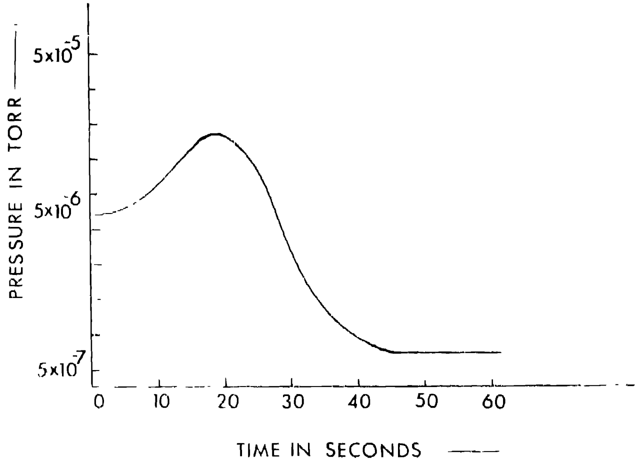

Fig 1 The gettering action of gadolinium.

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